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REPORT 2021

CROSS-INDUSTRY BENEFITS AND CAPABILITIES OF COMPUTER VISION

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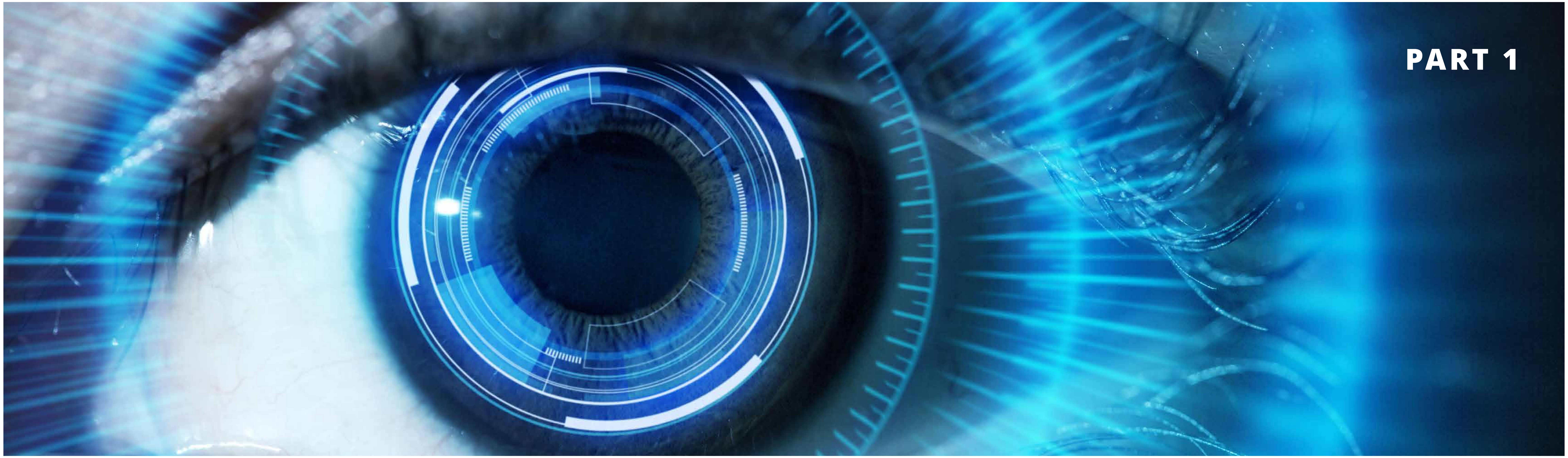
EXECUTIVE SUMMARY

With every passing year, artificial intelligence (AI) and machine learning (ML) are becoming more advanced. Having achieved stunning precision in processing various types of data, today, AI is no longer a promising technology but an essential element of a future-proof digital strategy.

Computer vision is one of the most prominent AI-based technologies that vividly demonstrates the capabilities of today's algorithms. It has found its application in manufacturing, automotive, retail, agriculture and continues to win over new verticals.

In this comprehensive report, you will find:

- **An in-depth review of the current state of the global computer vision market.**
- **Main challenges for implementing computer vision and how to avoid them.**
- **A comprehensive analysis of vision systems application across industries.**
- **A detailed guide on key components of computer vision technology.**
- **Cross-industry case studies on how AI-powered visual solutions favored businesses worldwide.**

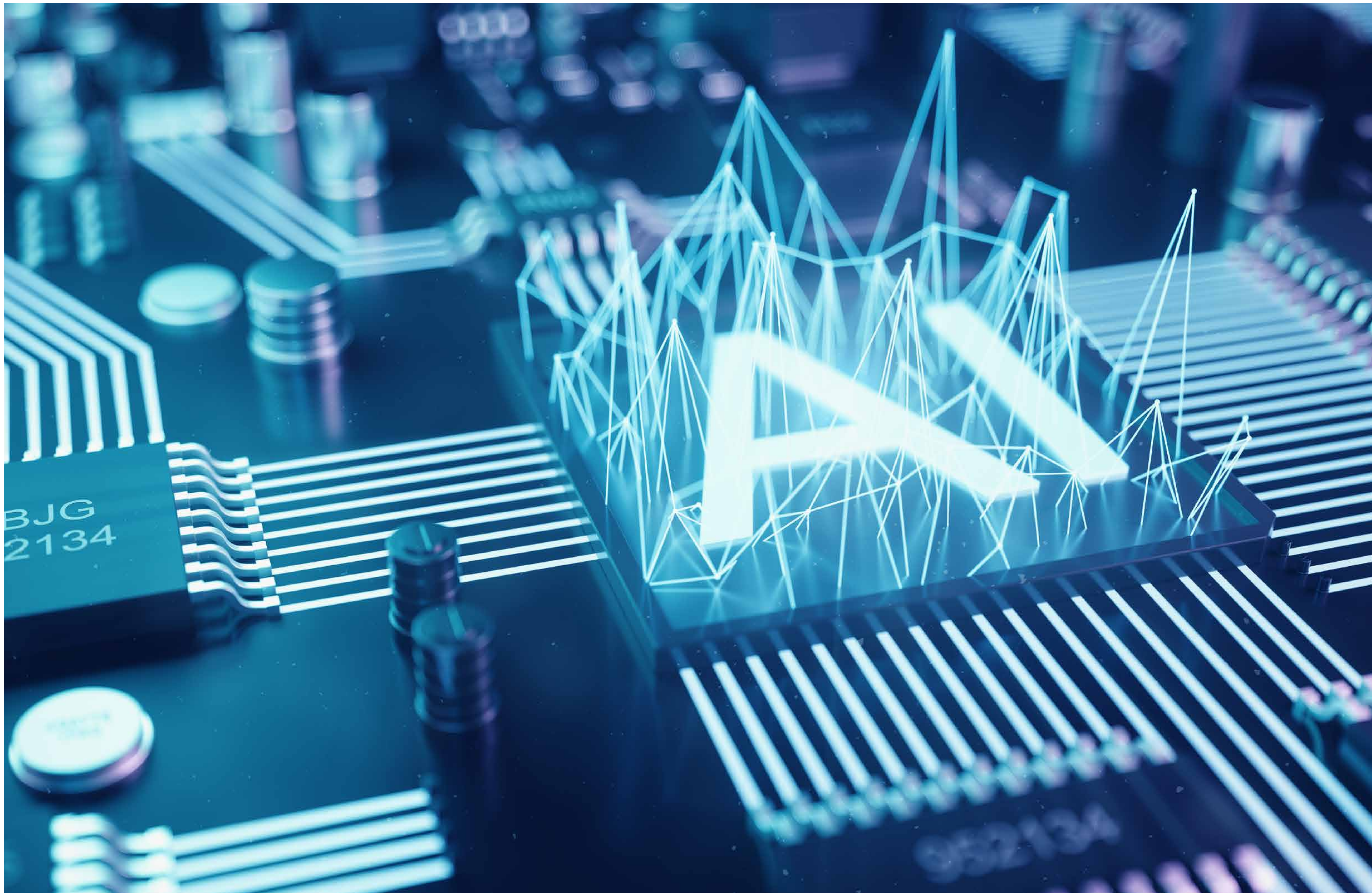


Comprehensive Review of Global Computer Vision Market

Ripping the Benefits of Advanced Computer Vision

The rapid adoption of process automation and the need to delegate routine operations to intelligent systems have raised the interest in computer vision and ensured its recognition as advanced enterprise-level technology.

Computer vision, *as defined by IBM*, is a field of artificial intelligence (AI) that enables computers and systems to derive meaningful information from digital images, videos, and other visual inputs. Based on that information, AI-powered systems provide companies with recommendations and insights to help eliminate downtimes, improve operational efficiency, cut costs, enhance security, and much more.



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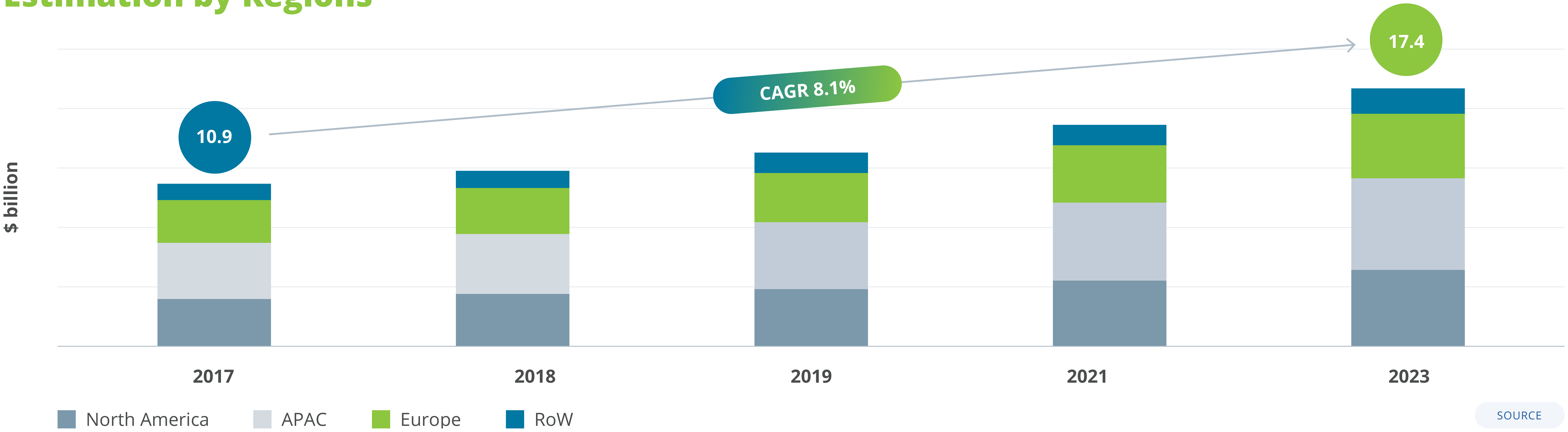
Global Computer Vision Market Dynamics

The global computer vision market is expected to reach $17.4 billion by 2023, at a CARG of 8.1% from 2017 to 2023, as stated by the MarketsandMarkets report. APAC and North America are considered the leaders in computer vision adoption, with Europe slowly yet steadily increasing its share in the market.

Computer Vision Market Size & Growth Estimation by Regions



SOURCE

Key Factors Driving Computer Vision Market Growth

The industrial vertical, particularly the automotive and manufacturing sectors, greatly contribute to the computer vision market growth. The rapid adoption of process automation and quality inspection is seen as the major impact factor to drive the market, retaining its significance back from 2016 and up to 2027. At the same time, the need for application-specific computer vision systems makes the technology relevant to a variety of industries.

Key Market Drivers Impact

Market Drivers	2016-2019	2020-2023	2024-2027
	Impact		
The rapid adoption of process automation and inspection management in manufacturing	High	High	Very High
The surge in demand for vision-guided robotic systems	Moderate	High	High
Growing need for application-specific computer vision systems	Moderate	High	High
Increasing demand for hybrid and electric cars	Low	Moderate	High

Very High High Moderate Low

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Computer Vision Adoption across Verticals

Manufacturing

One of the leading sectors to utilize computer vision. The implemented technology allows for vast application options: from predictive maintenance and incident monitoring to improved quality assurance. For example, Johnson & Johnson could eliminate downtimes and reduce waste on their production line by implementing a computer vision system.

Banking and Finance

Computer vision is yet to be widely adopted by the industry. However, the technology proves to be successful in fraud detection, biometric authentication, document processing, automated decision making, and more. Advanced solutions allowed a global bank to identify counterfeit checks, while CaixaBank deployed ATMs powered by facial recognition across Spain.

Automotive

The increasing demand for self-driving vehicles and intelligent safety systems boosted the evolution of computer vision solutions for automotive, with Tesla and Waymo being at the forefront. Advanced driver-assistance systems, equipped with smart cameras, are able to detect objects and people, assess the environment, and help the car navigate complex roads.

Healthcare

While AI cannot replace a trained medical specialist, it can greatly contribute to reducing routine tasks. Cutting-edge computer vision solutions can automate medical image processing, including CT and MRI, to help determine a diagnosis, provide real-life monitoring during surgeries, and detect abnormal health patterns. A solution, implemented at the Mount Sinai Hospital, accelerated CT scans interpretation with only about 1 second needed to identify a disease on a scan.

Retail

Retail has eagerly adopted computer vision and is taking advantage of its capabilities. Nationwide chains, like Walmart and Amazon Go, put to use AI surveillance systems to track shoplifting, analyze consumers' behavior, automate checkout, and improve customer experience.

READ OUR ARTICLE TO EXPLORE THE VALUE OF AI FOR THE RETAIL SECTOR

Agriculture

Carefully trained computer vision systems can be of great use in a field that demands constant monitoring for the best result. An AI-powered solution allows for 24/7 crops and stock monitoring to timely detect diseases, pests, or insects, evaluate yield, automate feeding, weeding, and harvesting. Computer vision solution is said to help increase yield by 10%.

Dominating Use Cases in the Computer Vision Market

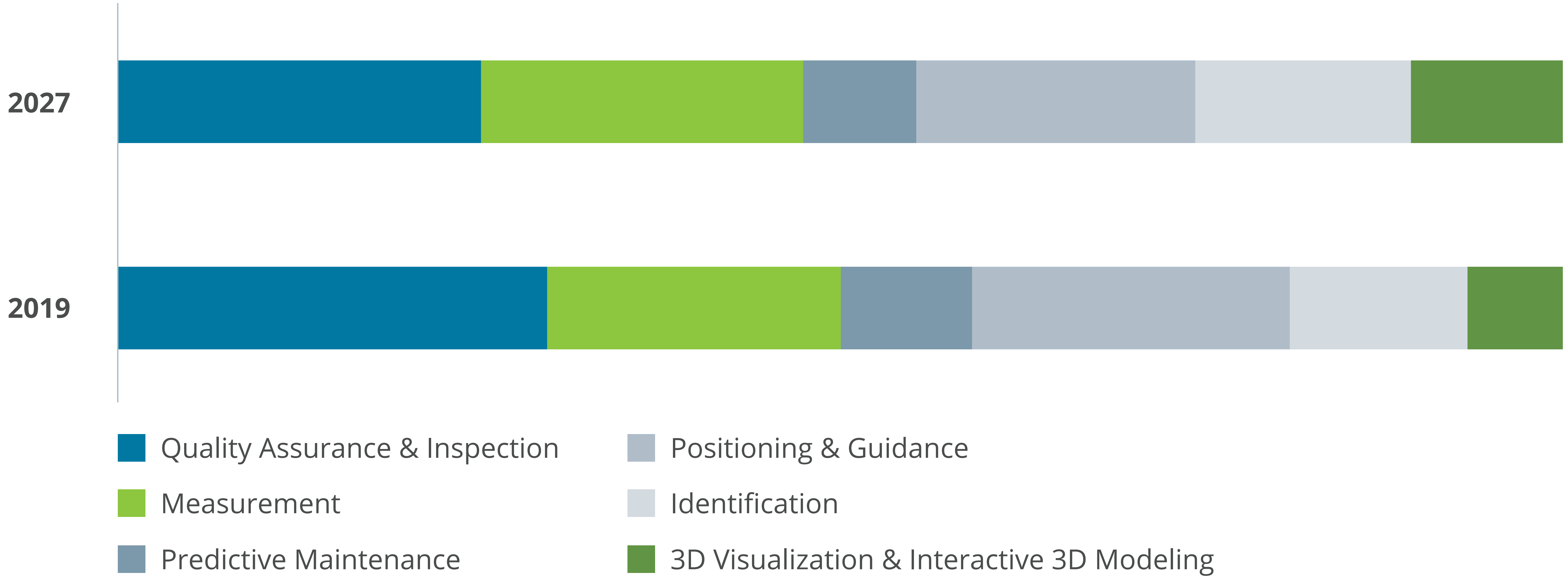
ASK OUR EXPERTS ABOUT WAYS TO UTILIZE PREDICTIVE ANALYTICS AND PREDICTIVE MAINTENANCE FOR YOUR BUSINESS

The continuously growing demand for process automation in the industrial sector is fueling computer vision adoption, particularly **quality assurance and inspection**. Computer vision solutions, boosted by deep learning and data analytics, enable inspection automation and ensure better quality for the manufactured goods.

Predictive maintenance, as well as **positioning and guidance**, are expected to gain a bigger market share by 2027, as compared with the current position. Combined with IoT, computer vision favors enterprises with highly reliable predictive maintenance solutions that can monitor production assets and detect potential malfunctions.

At the same time, the growing demand for precise image processing and analysis in the healthcare vertical and logistics is associated with the projected growth of the **3D visualization and interactive 3D modeling** segment of the computer vision market.

Computer Vision Global Market Share by Application



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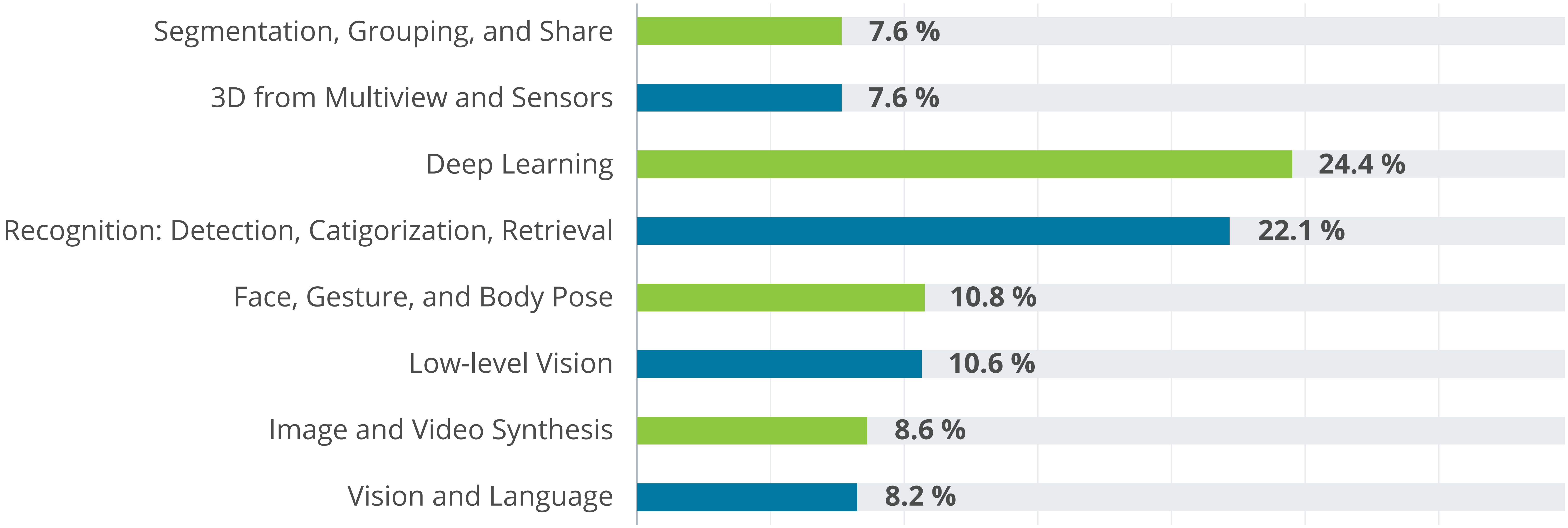
The Overview of Computer Vision Technologies

Computer vision, though focused on processing visual data, is not a homogeneous area. The extended capabilities, approaches, and technologies make computer vision a highly flexible tool that can be adjusted to companies' business needs.

However, deep learning and recognition have leaped forward and are now the most researched areas with 24.4% and 22.1%, respectively. Such a surge of interest is attributed to the continuously improving precision of deep learning models and the capability to work with complex data.

Recognition, which includes detection, categorization, and retrieval, owes its top position to recent advances in neural networks and new approaches to building effective visual recognition systems.

Main Areas of Research in Computer Vision



EXPLORE THE CAPABILITIES OF DEEP LEARNING AND WAYS YOUR BUSINESS CAN BENEFIT FROM ITS IMPLEMENTATION

SOURCE

Key Considerations for Implementing Computer Vision

Strategic Goals and Scalability

Prior to setting computer vision solution development in motion, it is essential to align the project with the business needs. While computer vision is flexible in terms of application, it may become very resource- and time-consuming to redesign, develop, and implement a new iteration if it requires drastic changes. Upgrading the solution would need new approaches to model training, more recent data to support it, and more powerful hardware to enable computing.

Solution:

Define primary business objectives and outline the expected result for a computer vision solution. This allows selecting the most fitting computer vision models and designing a solution architecture that can support further project development in the most efficient way. The hardware and software components are to be selected with enough capacity to ensure hassle-free scaling when required.

Customization

With the extensive capabilities of computer vision, it is tempting to adapt it to one's goals and objectives with a custom, never-seen solution. However, a made-from-scratch computer vision model or algorithm may turn out to be cumbersome and hard to maintain, while not performing with the desired effectiveness.

Solution:

The current AI market provides a multitude of pre-existing models, computer vision datasets, and databases that can favor your project. A visual AI solution is never out-of-the-box and typically requires fine-tuning to meet the needs of a particular enterprise, so you can add your code or algorithms where required. Yet consider whether it is essential and may any of the existing solutions cover your demand.

Data Quality

For the most part, the model performance depends on the quality of the injected data, especially during the training. To achieve high precision in visual processing on-site, the algorithms require a lot of high-quality data specifically related to the project that covers most of the scenarios and structure of the data.

Solution:

To compensate for lack of the real-life data, it is possible to turn to pre-trained neural networks most relevant to the project in development. However, when working with a demanding computer vision project, it is crucial to involve qualified data scientists that can enable efficient data preparation and management.

Hardware

An average setup of a hundred cameras can produce up to 260 million images per day, configured for 30 frames per second. All this voluminous data has to be properly processed with high-capacity hardware. This is especially critical for AI-based solutions that require real-time analysis and response, for instance, intelligent driver-assistance systems. At the same time, the quality of the input data depends on the surveillance system and cameras capabilities.

Solution:

To get the most out of the gathered data, one can rely on cloud computing to process images and videos with minimum investment into the on-premises equipment. Alternatively, most of the computing can be performed on the edge to enable security and compliance for sensitive data. A conservative estimate is the best approach to selecting on-premises hardware and equipment.

LEARN HOW TO AVOID PITFALLS IN IMPLEMENTING COMPUTER VISION IN OUR ARTICLE

SOURCE 1 SOURCE 2 SOURCE 3 SOURCE 4

The Business Value of Computer Vision

ACCURACY

State-of-the-art computer vision systems can ensure up to 90% of accuracy for image recognition.

RELIABILITY

AI-powered vision systems allow for 24/7 intelligent monitoring and data processing, eliminating the human factor of fatigue and reducing relevant risks and errors.

IMPROVED EFFICIENCY

Process automation helps reduce the cycle time of operations and achieve uninterrupted processes.

REDUCED COSTS

Automated operations and flexible configuration lead to reduced maintenance costs, eliminate downtimes, and cut down extra expenses on staff training.

WIDE RANGE OF USE

Thanks to their industry-neutral nature, computer vision systems are applicable to any domain – from plants and banks to healthcare.

DATA-DRIVEN DECISIONS

With the vast volumes of processed data, enterprises can make informed decisions based on behavioral analytics, identified patterns, and quantitative analysis.

REAL-TIME ANALYTICS

Processed instantly, the real-life data can be utilized to take immediate actions according to the solution scenarios.

Computer Vision Trends Overview

Ensuring Public and Workplace Safety

Implementing intelligent monitoring solutions to detect personal protective equipment

Closed-Loop Vision Systems

Wider adoption of output-dependent computer vision solutions to help automate control process parameters

Integration with Edge Computing

Optimizing computer vision models performance and ensuring data compliance with edge computing

Automating Anomaly Detection

Deploying AI-powered visual inspection solutions to ensure uninterrupted processes and improved quality assurance

Embedded Vision

Incorporating image capture and processing abilities to a single device

Emotion AI

Detecting people's emotional response by analyzing facial features and eye movements

Incorporation of Sensor Data

Providing a holistic view by integrating asset monitoring and diagnostics data with video insights

Mixed Reality

Driving the immersive experience evolution with AR, VR, and MR development

Computer Vision as a Service (CVaaS)

Introducing a pay-as-you-go model for the cloud-hosted solution to benefit from the latest computer vision models with a reduced initial investment

DISCOVER HOW INFOPULSE ENABLES HIGH STANDARDS OF PUBLIC SAFETY WITH A COMPUTER VISION SOLUTION FOR MASK WEARING DETECTION

Cross-Industry Analysis

BANKING & FINANCE

Advancing Innovation in Financial Services with Computer Vision

Starting from the 2010-s, the BFSI industry has been slowly but steadily embracing AI technology and its wide area of use. Computer vision is the recent trend promising to benefit both financial business and consumers. Propelled by the soaring digital economy, the potential of this technology goes beyond process automation and reduced costs, offering significant value in terms of cybersecurity, customer management, and authentication systems.

Despite the attractive long-term benefits, financial services market players are slow and cautious about implementing the CV technology to its full extent. The major obstacle lies in the complexity of computer vision platforms that require a complete modernization of the traditional legacy systems banks still rely on.

Key Challenges for the Financial Industry

Legacy Systems

A majority of financial institutions still utilize legacy systems, which may be incompatible with modern platforms and technologies

High Maintenance Costs

Bulky on-premises infrastructure support and maintenance are costly and skill-intensive

Compliance and Data Privacy

The raising amounts of data make regulatory compliance more complex and challenging

Shifting Customer Demands

Modern consumers demand personalized approach and 24/7 flawless support

Extra Competitive Market

Fierce competition from tech-savvy market players like fintechs

BANKING & FINANCE

Practical Applications and Business Value for Financial Services

Computer vision is a universal technology that can be implemented in retail, commercial banking, and insurance. AI solutions can benefit both businesses and customers by offering automation, increased efficiency, and a seamless user experience.

Use Cases for the Financial Industry

- Biometrics and image recognition for authentication and fraud prevention
- Automated document classification
- Image analysis for the property investigation
- Digital and remote customer onboarding

What Are the Benefits of Computer Vision?

- Optimized and automated workflow
- Improved customer service
- Reduced costs and paperwork
- Advanced cybersecurity backed up by biometric identification
- Streamlined onboarding processes
- Enhanced data accuracy

MANUFACTURING

A Crucial Role of Smart Automation in the Manufacturing Industry

Manufacturing has been capitalizing on automation since the industry inception. Current technological advancements are fueling this trend further with digital transformation. Computer vision is part of the Industry 4.0 revolution aimed at making machines 'smarter' across all supply chain levels by using data from available sources to streamline the processes.

Computer vision enables smart automation by collecting, processing, and analyzing data from visual inputs. The new imaging techniques paired with machine learning arm algorithms with the ability to make complex decisions with more accuracy and without human involvement. For example, computer vision is invaluable when it comes to checking products for defects – the process, which requires constant focus and attention to detail.

A glass manufacturer saves $1 million quarterly by adopting the Spyglass Visual Inspection system that helps detect flaws in the production process with precision. The system eliminates the rate of 'false positives' when shadows are confused for cracks by human workers.

Current Challenges in the Manufacturing Industry

Growing Complexity of Supply Management and Processes

Modern production requires agile methods and new technology, which are hard to integrate into legacy systems

Lack of Skilled Workers

An aging workforce and a shortage of younger workers lead to the skills gap in the manufacturing

Increasing Needs for Automation

To reduce costs and elevate efficiency in order to stay relevant on the market, manufacturers need to implement full automation of their infrastructure

Transparency Demands from Stakeholders

Clients, investors, and suppliers inquire more visibility and real-time updates to manage risks and opportunities

MANUFACTURING

Future-Proofing Manufacturing with AI-Powered Solutions

LEARN HOW INFOPULSE ENABLED AI-DRIVEN DATA RECOGNITION FROM OLD GAUGES FOR A METAL MANUFACTURER

Fast-paced development is happening across all fields of computer vision technology, including imaging techniques, CMOS sensors, embedded vision, robot interface, new data transmission standards, and more.

Apart from the apparent benefits of accuracy, efficiency, and optimized costs, integrating computer vision into smart factory amplifies innovation and scaling opportunities.

Converting Computer Vision Opportunities into Actionable Solutions

- Enhanced manual assembly with work analysis
- Higher level of accuracy in text and barcodes scanning
- Faster product and components assembly
- Automated package inspection with 3D image processing
- Predictive maintenance using big data analytics
- Reduced defects and cost overheads
- Improved worker safety driven by minimized human involvement

ECOMMERCE & RETAIL

Revolutionizing Retail with Data-driven Digital Transformation

Given the fierce competition among retailers, customer experience nowadays is a crucial success factor. Vast amounts of data help businesses optimize and personalize customer journey, informing all the retailer's objectives – from profit margins to client retention. Computer vision is an enabler of smart automation and the transformation of physical stores. It's not just the giants like Walmart or Amazon that incorporate machine vision solutions to speed up the checkout process or eliminate it completely.

The technology is gaining momentum in the global arena, driven by the ease of implementation and growing applications. According to the Annual Retail Technology Study by RIS, only 3% of retailers have adopted computer vision, and 40% are planning to do so in the near future. With shelf-scanning robots and smart cameras analyzing customer behavior, the retail industry can target its most enduring pain points and head into the future of flawless service.

About 40% of retailers worldwide are to invest in computer vision

Retailers' Challenges Requiring Urgent Solutions

- Inventory management with 'out-of-stock' problems
- High demands for frictionless customer experience
- Relentless competition and rising marketing costs
- The COVID-19 pandemic restrictions and regulations

ECOMMERCE & RETAIL

Disruptive Potential of Computer Vision in Retail

Offline retail stores are still the preferred option among shoppers. Computer vision solutions aid in analyzing vast visual datasets and transforming them into actionable insights for optimizing the store experience. It can point which sections need improvement in terms of design and placement, recalibrate the marketing strategy according to customers' behavior analysis, and speed up the checkout process.

READ OUR CASE STUDY TO DISCOVER HOW A RETAIL GIANT REDUCED MAINTAINANCE COSTS AND ENHANCED CUSTOMER EXPERIENCE WITH A CV SOLUTION

Using Computer Vision in the Retail Industry

INVENTORY MANAGEMENT

Computer vision solutions can boost the efficiency of this complex process with timely notifications and updates

SELF-CHECKOUT

Customer service automation is becoming an industry standard

STORE LAYOUT

The technology helps businesses identify 'hot' and 'cold' areas of the store, allowing for insights into purchase patterns

MASK DETECTION, TEMPERATURE SCREENING, OCCUPANCY VERIFICATION

A great tool helping to check whether shoppers are wearing masks and comply with the mandatory pandemic requirements

ENERGY & UTILITIES

Digitalization Reshaping the Energy Sector

The global shift from fossil fuels to renewable energy sources has been actively revolutionizing the industry. On the one hand, the energy sector is going through digital transformation to leverage the AI capabilities; on the other hand, the industry needs to meet higher demand for power supply caused by the growing economy-wide digitalization. Computer vision paired with IoT and Big Data analytics is bound to increase renewable energy generation and management efficiency.

A critical element of global infrastructure, the energy industry stumbles upon challenges that can lead to national consequences. The variability of electricity demand and levelized energy cost makes it hard to predict economic feasibility of different energy sources.

ENERGY & UTILITIES

Balancing Energy Efficiency with AI-Powered Solutions

Big Data, machine learning, and computer vision help reduce uncertainty in energy production and bring cost optimization and reduced errors to the energy sector management.

Computer Vision Use Cases

OBJECT AND ISSUE DETECTION

Drones are able to make images of the grids and other equipment to identify possible maintenance needs

IDENTIFYING BEST SOLAR POWER PRODUCTION SITES

With the help of satellite imagery and aerial photography

ASSET MONITORING

Computer vision provides highly accurate visibility of the equipment without human involvement

AGRICULTURE

Precision Agriculture of the Future

A global food demand goes hand in hand with mounting scarcity of resources. Intelligent technologies are already helping to tackle this universal problem to keep the balance between crop yield and better efficiency. Properly collected and analyzed data help farmers cope with the climate change challenges, prevent plant diseases, and meet the rising demand for quality food.

Computer vision and other AI-powered solutions make up ‘precision agriculture’. A system of drones, sensors, and cameras coupled with machine learning algorithms conducts analyses, makes predictions, and suggests optimal industry management and support solutions.

Computer Vision Solution in Agriculture

Crop Monitoring

Capturing data on field condition with the help of a computer vision-powered drone

Forestry Management

Analyzing deforestation activities based on aerial and satellite images

Livestock Management

Recognizing, counting, and monitoring livestock with autonomous drones

Spraying Pesticides on Crops

Precise crop detection and spraying against harmful agents from drones

Yield Prediction

Collecting and analyzing data on soil condition, nitrogen levels, moisture, as well as seasonal weather to predict yield results

Grading and Sorting Crops

Precise examination of crops for quality and allocation purposes

HEALTHCARE & PHARMACEUTICALS

Life-Saving Potential of Computer Vision in Healthcare

The medical industry has been integrating AI-backed solutions across various sectors. With the capability to analyze complex images, the potential of computer vision in healthcare is invaluable in the diagnosis. Machine learning algorithms excel humans at identifying certain patterns that help predict medical outcomes and save patient's life. Detecting atypical symptoms and false positives reasonably in advance allows doctors to get accurate results and assign the appropriate therapy.

Use Cases in the Healthcare Industry

- **Faster Diagnosis**
  Timely diagnosis aid in preventing fatal consequences
- **Accurate Measurement**
  Precise image scans of blood loss and suction canisters that require immediate action
- **Complex Pattern Detection**
  Identifying patterns omitted by the human eye
- **Cancer Screening**
  Detecting precancerous lesions via tissue imaging
- **Interactive 3D Visualization**
  Computer vision improves medical imaging accuracy

Core Functions & Capabilities of Computer Vision

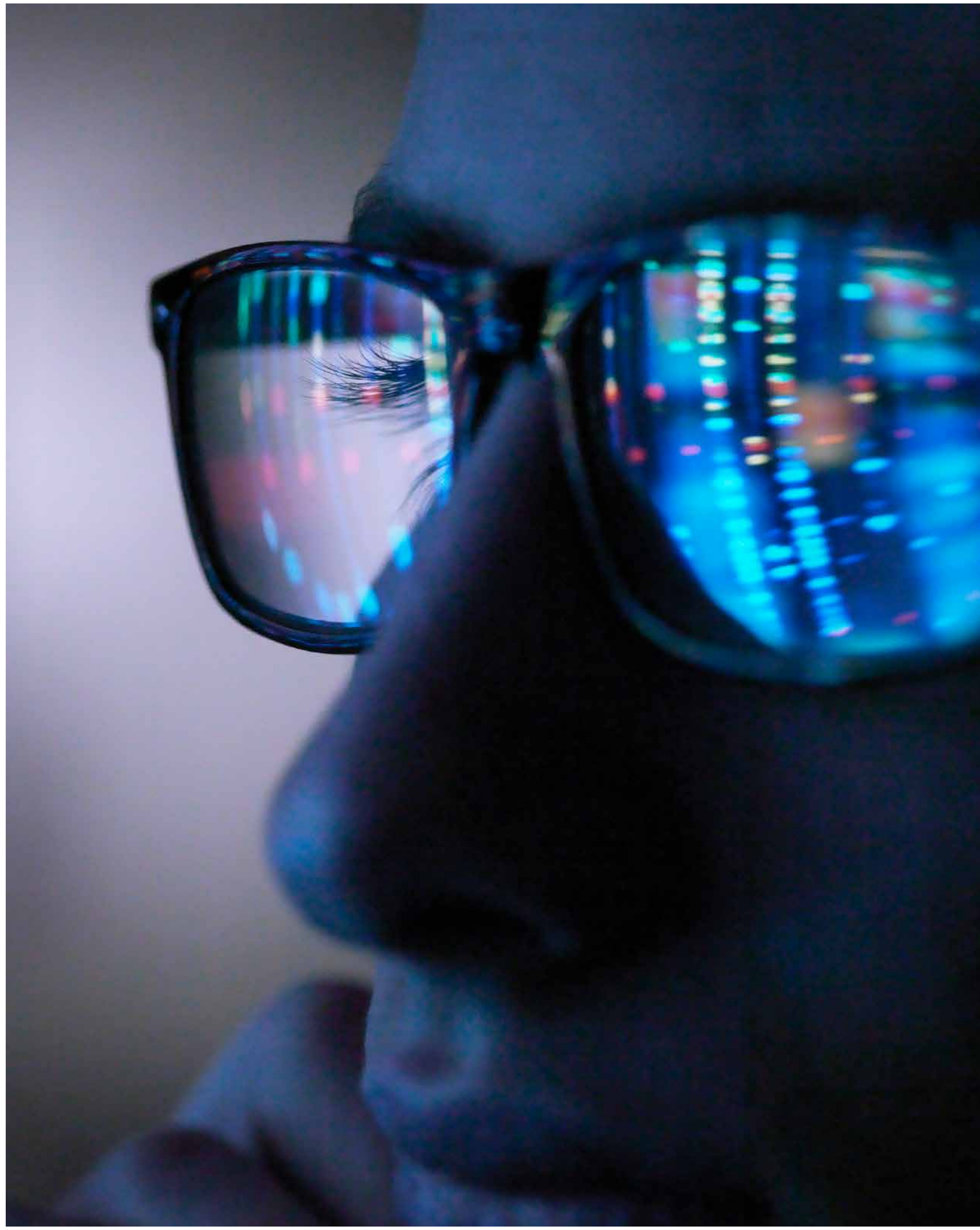
How Does Computer Vision Work? Core Functions & Capabilities Explained

Computer vision (CV) is supplied with large amounts of data, which is then continuously processed until CV can identify distinctions and accurately recognize the images. For example, to enable early detection of cancer lesions, CV models are fed with high volumes of images labeled either as healthy or cancerous and then trained to accurately detect the afflicted tissue. These advanced capabilities of computer vision are powered by two fundamental technologies:

- **Deep learning** – algorithms that repeatedly execute certain tasks and gradually improve the outcome through progressive learning.
- **Convolutional Neural Network (CNN)** – a set of algorithms, inspired by the visual cortex of the human brain that is used to analyze visual imagery.

Deep learning algorithms enable a computer to "look" at the visual data, understand its context, and teach itself to differentiate the images. ***CNN*** helps the computer to "look" by breaking down the visuals into pixels that are then tagged or labeled. Subsequently, CNN uses the tags and labels to perform calculations and predict what it "sees". At first, CNN identifies simple shapes and edges, then fills in the information and runs multiple iterations until the predictions are true. The CNN-based predictions facilitate pattern recognition and image classification for CV.

However, CNN is only used to understand single images. When it comes to video analytics, a ***recurrent neural network*** (RNN) is used to help computers understand how images in a series of frames are related to one another.



The next section of this report provides an in-depth overview of the CV core functions, including execution techniques, types of algorithms, methods, and capabilities of these functions.

Image Classification

Image classification is one of the core CV functions, which accepts input images and labels them into one of the predefined classes. More precisely, the image classification model is trained to predict that a specific image belongs to a certain class (human, animal, car, etc.).

Early image classification analyzed raw pixel data, i.e., the computer broke down the images into individual pixels.

However, this model is now inefficient. The position of the object, varying lightning, or different camera angles and focus can produce fluctuation in raw pixel data.

Modern-day image classification is powered by deep learning and CNN, which enable swift and precise image labeling and categorization.

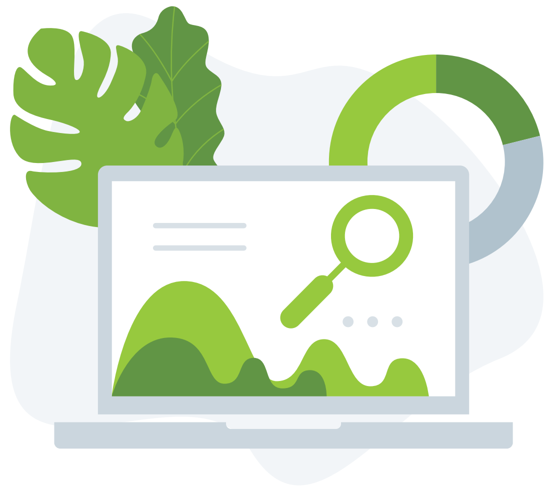
The process of image classification includes the following stages:

IMAGE PRE-PROCESSING

This stage is designed to eliminate image distortions and enhance its features so that CV models can process high-quality data.

OBJECT DETECTION

This process outlines the localization of objects within the image.



FEATURE IDENTIFICATION AND TRAINING

At this stage, CV identifies the object's unique features. Later these features will help CV differentiate between image classes.

OBJECT CLASSIFICATION

CV categorizes the objects into predefined classes by using one of the classification techniques.

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Image Classification Techniques

SUPPORT VECTOR MACHINE

This technique separates the classes by using a linear boundary.

ARTIFICIAL NEURAL NETWORK

A sophisticated system that detects specific trends and patterns in the given data and classifies it accordingly.

SOFT (FUZZY) CLASSIFICATION

Provides each pixel with a measure of a similarity degree for every class.

GENETIC ALGORITHM

Classifies the images by relying on processes inspired by natural selection, like heredity, mutation, and crossover.

Image Segmentation

Image segmentation is a fundamental part of CV and digital image processing, aimed at simplifying the analysis of the visual content. In essence, image segmentation enables the processing of the meaningful parts of an image on a pixel level. It breaks down an image into sets of pixels (segments) and groups the segments that have similar features and properties (color, texture, etc.). Once the entire image is segmented, CV can easily distinguish the foreground from the background, accurately identify the location of objects (such as cars and pedestrians), and recognize boundaries between these objects.

Key Techniques of Image Segmentation

Thresholding

A simple segmentation technique that separates the object from the background by comparing pixel value to a specific threshold.

Edge Detection

Outlines the edges of an image by detecting brightness variations and other discontinuities, like color mutation or texture changes.

Segmentation Based on Clustering

An unsupervised algorithm that is used to segment the interest area from the background.

Mask R-CNN

Cutting-edge segmentation technique that classifies objects by using bounding boxes and produces segmentation masks for each region of interest.

The two main approaches to image segmentation are:

- **Instance segmentation** – detects each distinct object of interest in an image. For example, each vehicle or person is segmented as an individual object.
- **Semantic segmentation** – identifies uncountable and amorphous objects such as sky, forests, water, etc.

Object Detection

Object detection is a technique that combines image classification and objects localization to identify objects and their positioning within an image or a video. This technique is widely used in numerous CV tasks, such as face detection, activity recognition, object tracking, or image annotation. Object detection draws bounding boxes around the objects and labels them into certain groups, which allows to precisely determine the objects, their location, and movement.

Object detection may be based on one of the two possible approaches:

- The first one is the **ML-based approach** that extracts the object features, like color histogram, and identifies the group of pixels that may belong to the object. The discovered features are then channeled into a regression model that predicts the object's location.
- The second approach is more advanced, as it is based on **neural networks**. CNNs perform end-to-end unsupervised object detection, where features don't need to be defined and extracted separately.

Types of CNN-driven Object Detection Algorithms

R-CNN

Utilizes selective search of regions of interest (ROI) that represent the boundaries of the object. Each ROI is fed through the neural network to produce output features that are classified by support vector machines to identify the type of the object.

Fast R-CNN

An upgraded algorithm that implements ROI Pooling that extracts each ROI from the network's output tensor, reshapes them into a fixed size, and classifies them.

Faster R-CNN

The most advanced algorithm that does not use selective ROI search but integrates ROI generation into the neural network. This algorithm enables real-time object detection.

Facial Recognition

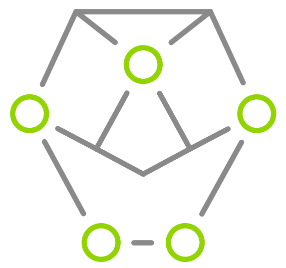
Facial recognition technology is used to identify and authenticate a person by capturing and processing unique facial features from a digital image or a video and matching them against a respective faceprint database. The technology is categorized as biometrics, as it involves the analysis of physical or behavioral characteristics, including the position, size, and shape of the eyes, nose, jaws, or specific facial expressions.

Facial recognition has developed rapidly over the last decade. Today it has a broad spectrum of applications, ranging from law enforcement and video surveillance to enabling payment verifications and access to mobile devices, applications, or social media platforms.

How Does Facial Recognition Work?

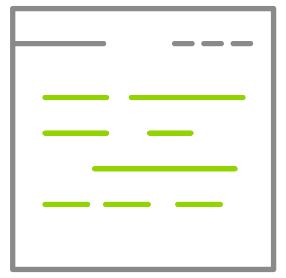
FACE DETECTION & ALIGNMENT

CV outlines the human face, its position, angle, and facial features on an image or a video.



FEATURE EXTRACTION

The technology proceeds to distinguish multiple facial landmarks, like mouth corners, eye gap, etc.



REPRESENTATION

All the key facial features are converted into a unique code, called a faceprint.

FACE MATCHING & IDENTIFICATION

The unique code is compared against a faceprint database to identify the user.

Facial Recognition Methods

Traditional Methods

These methods involve the tracking of holistic or local features within an image or a video.

Neural Networks

This method utilizes sophisticated CNN algorithms to accelerate facial recognition.

Gabor Wavelets

This method simulates human eyesight and accurately identifies changes in illumination and positioning.

Face Descriptor

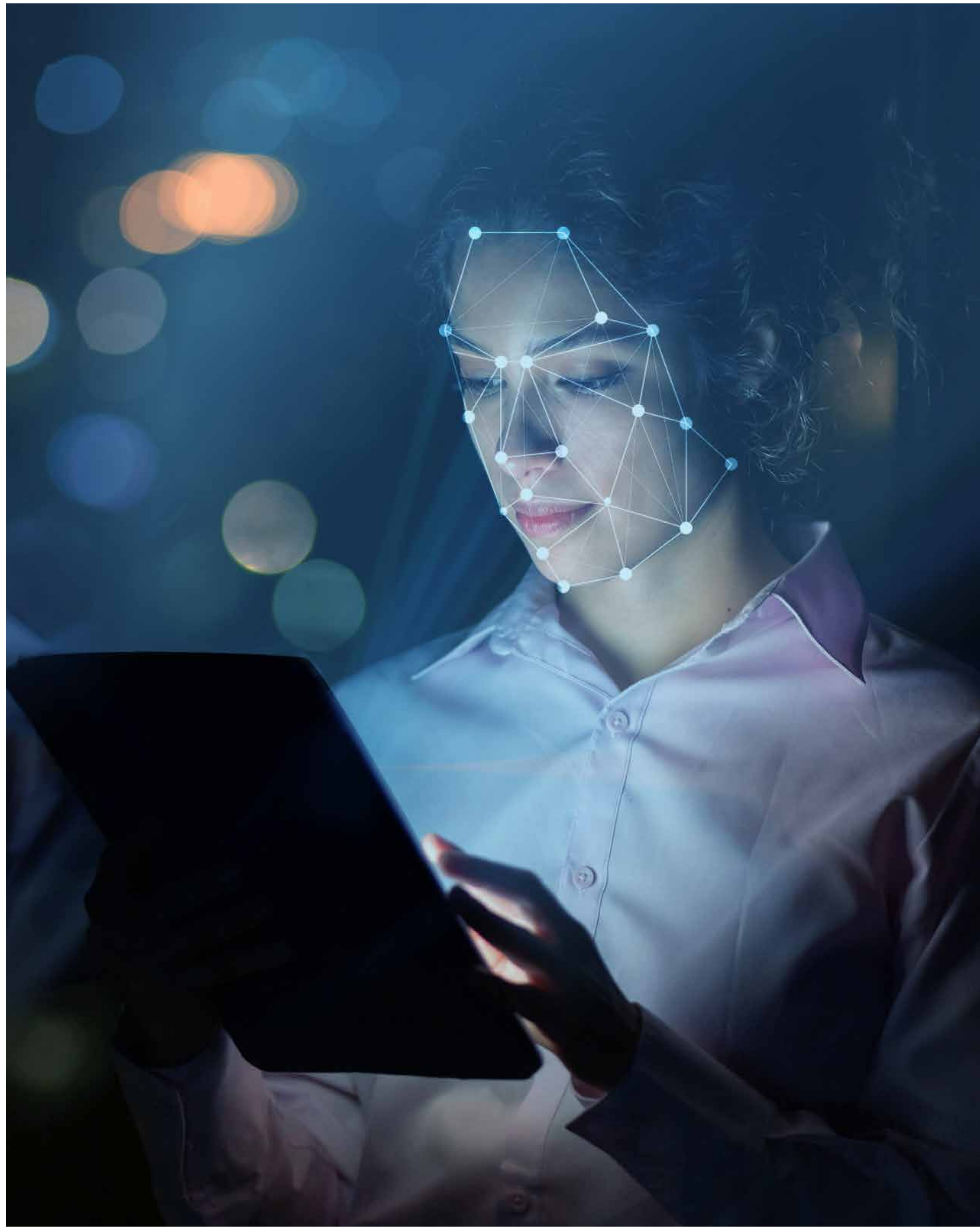
Used to analyze both local and global properties of a face image.

3D Facial Recognition

Utilizes 3D geometry to analyze lightning, facial expressions, makeup, and other features.

Video-based Facial Recognition

Analyzes facial characteristics in motion to identify people in videos.



Intelligent Video Analytics

Intelligent video analytics leverages CV and deep learning to automatically process the content of digital videos, identify events of interest, track patterns, and detect anomalies in real-time. Intelligent video analytics comprises core CV functions, such as object detection and localization, which are augmented by more sophisticated features, like object tracking, pose estimation, and action classification.

CV-driven video analytics has a broad spectrum of valuable applications across different industries, including:

PUBLIC SAFETY

Facial recognition of criminal suspects, violence detection, and crowd management.

TRANSPORTATION & LOGISTICS

Traffic flow monitoring, driver's activity recognition.

MANUFACTURING

Protective equipment compliance, employee's health condition monitoring and alerting.

SMART HOMES

Gesture command recognition, smoke, and fire detection.

RETAIL

Customer flow heatmaps, attention analysis.

HEALTHCARE

Patient monitoring, emotion recognition.

Intelligent Video Analytics Capabilities

Directional Motion

Enables to quickly identify areas of interest by triggering an alarm once a motion is detected in a certain direction.

Adaptive Motion

Motion detection that calibrates to scene conditions, allowing to distinguish objects of interest from other movements within a scene (rain, snow, etc.).

Vibration Removal

Reduces video shaking effect when the cameras are subject to vibration.

Object Removal

The system triggers an alarm once a stationary object is removed from a specific scene.

Object Counting

Counts every object when motion is detected in a specific direction. This capability is widely used in the public sector or retail, e.g., to calculate the number of customers.

Camera Sabotage

Triggers an alarm when a video is compromised, e.g., when the camera is intentionally removed from a fixed scene.

Abandoned Object

Activates an alarm when a stationary object appears and remains in a particular scene.

Loitering Detection

Notifies the user when objects (people, vehicles, etc.) remain in a defined zone for a longer period than user-defined settings allow.

Auto Tracking

Tracks vehicles or humans entering or stopping in user-defined zones.

Types of Motion Tracking Techniques

FIXED CAMERA BLOB TRACKING

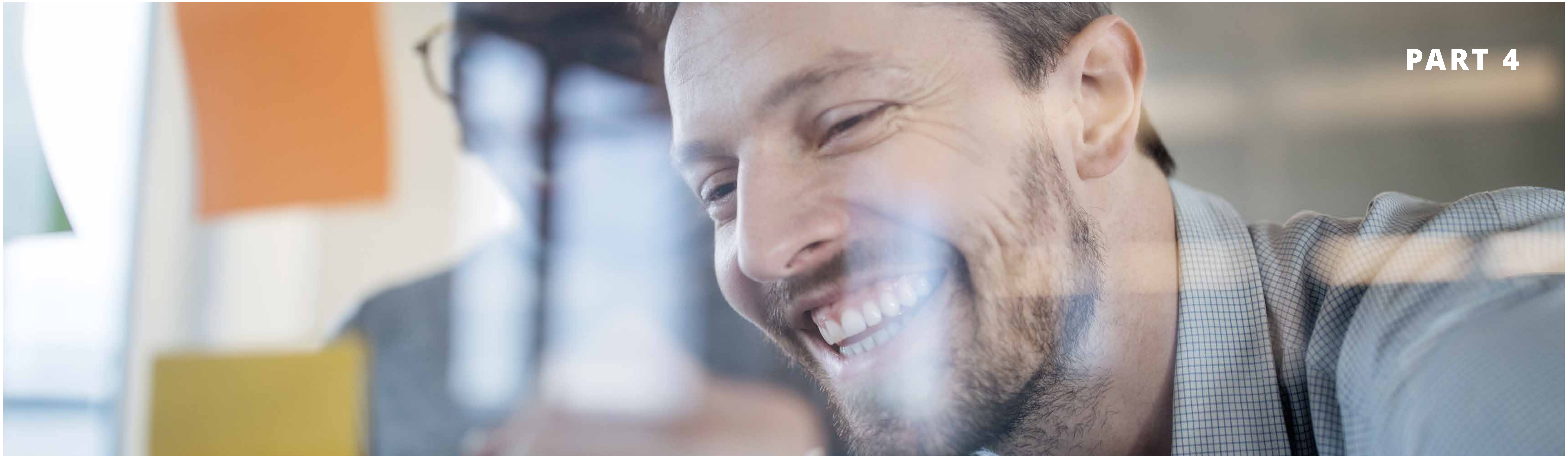
When the camera is in a fixed position, there is no egomotion (camera motion relative to a rigid scene). In such cases, the background is subtracted, and objects are identified by finding blobs that overlap in subsequent frames.

CORRELATION MATCHING

This technique is based on normalized cross-correlation (NCC) that is used to track objects in different time frames.

HISTOGRAM TRACKING

Color histograms are tracked and analyzed to identify objects within a video.



Computer Vision Use Cases and Success Stories

Computer Vision Applications Across Industries

Computer vision is versatile in its applications across various industries. By processing and analyzing all types of image and video formats, this technology goes beyond automating repetitive processes and offers revolutionary approaches to utilizing Big Data and improving decision-making efficiency.

At this point, AI has surpassed humans' performance levels when it comes to detecting complex patterns on large volumes of data. For example, **in financial services**, computer vision can aid in predicting and preventing potential fraud and optimize the process of claim investigation in insurance. **Retailers** also see a lot of potential in the technology that can reinvent customer service with automation. Furthermore, machine vision boosts the **manufacturing industry** by improving defect detection rates by 90%. Utilization of enhanced vision in **healthcare** allows doctors to save lives by performing more accurate medical examinations and preventing fatal diseases.

Use Cases in Top Six Industries

FINANCIAL SERVICES

Financial and personal data protection, property evaluation, insurance claim verification

GOVERNMENT

Smart cities, security intelligence

HEALTHCARE

Predictive diagnosis, medical imaging, patient monitoring

MANUFACTURING

Object recognition, defect detection, supply chain optimization

RETAIL

Customer behavior analysis, inventory management, automated self-checkout

AGRICULTURE

Defects scanning, properties estimation, crop yield prediction

CASE STUDY #1

A Computer Vision Solution for a National Railway Administration

The concept of Smart Cities is gradually realized through disruptive technologies. Gorilla Technology, an edge AI solution provider, in partnership with Intel has developed a computer vision solution for a national railway administration to enhance public safety and visibility across its networks.

Solution:

Intelligent Video Analytics Recorder (IVAR) was implemented across 300 stations, each handling 17,000+ people daily. The system monitors foot traffic and analyses surveillance data for abnormalities, incidents, and needs to adjust staffing, while its IoT sensors can detect fire and restricted area breaches. By implementing IVAR, the railway administration has registered a significant decline in crime rates and incidents.

CASE STUDY #2

Computer Vision to Automate Automotive Assembly in Manufacturing

Industrial IoT adoption in factories and plants is gaining momentum. Automation, which has always been an integral part of manufacturing, is reaching new heights of innovation with intelligent robotics. NexCOBOT, an IoT system integrator, has combined computer vision with Intel AI technology to develop a solution that would allow robots to conduct automotive assembly. It's a high-mix, low-volume manufacturing task with custom and complex requirements, where traditional machine vision (MV) can't be implemented.

Solution:

Modular and compatible with manufacturing environments, a solution by Intel was implemented on basis of a robot assembling LED modules without human involvement. The MV solution analyzed photos taken and classified the correct modules and colors. After confirmation, the robot plugged and tested a module and prepared the line for production. Automating tasks in changing environments allows supervisors to track results from the back office without being exposed to danger on the factory floor.

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CASE STUDY #3

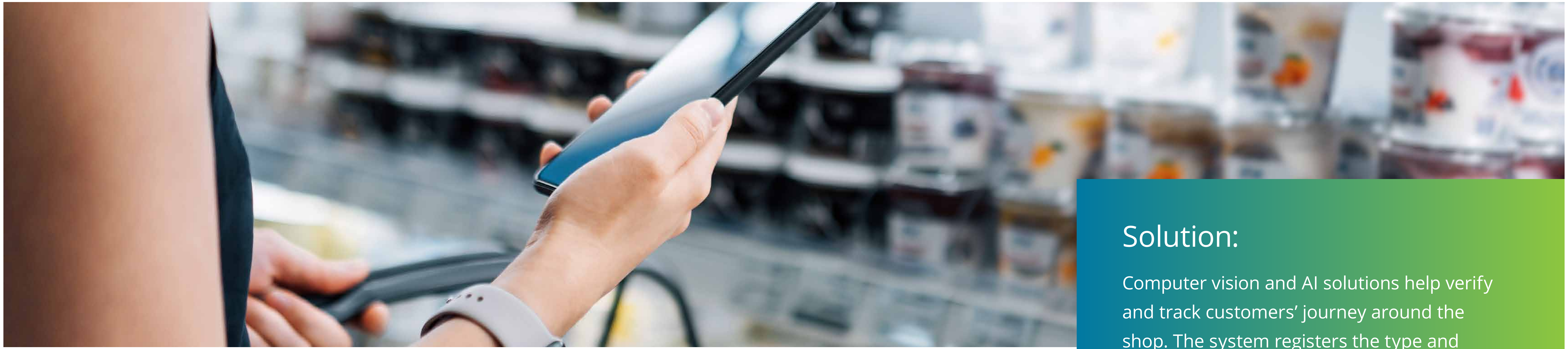
Data-Driven Transformation of Brick-and-Mortar Retailers

Demand for flawless experience goes beyond online customer journeys, and modern consumers expect to get the same comfort and convenience from offline shopping. Data and AI-powered means for its analysis have already been optimizing the customer experience and inventory management. In collaboration with the computer manufacturing company Advantech, Intel has devised an UShop EIS AI system, an AI Video technology tool to help retailers drive digital transformation.

Solution:

UShop EIS AI system designed by Intel utilizes computer vision to capture and analyze customer behavior around a shop and provide insights about product trends (demand, interest, rejection). Machine learning algorithms identify human silhouettes as they navigate the store and form a heatmap of customers' interactions with products. Implementing this advanced analytics solution provides managers with actionable data on the shop performance and ways to streamline staffing and personalized service.

CASE STUDY #4



Advanced Shopping Technology without Checkout

Incompatible at first thought, automation and personalization are now hot trends in the retail industry. Stores equipped with computer vision, deep learning algorithms, and IoT sensors – all powered by AI, are growing at a moderate pace. Amazon Go is a well-known example of a company utilizing disruptive technology for a frictionless experience on the customer side and advanced analytics on the business side.

Solution:

Computer vision and AI solutions help verify and track customers' journey around the shop. The system registers the type and number of products put in the bag while making a note of those put back on the shelf. When the customer is done shopping, they exit the store without the need to go through the checkout process. The transaction happens automatically from the person's bank account without extra actions. Even though the potential of intelligent automation is enormous, there are still some privacy concerns that require additional improvement.

CASE STUDY #5

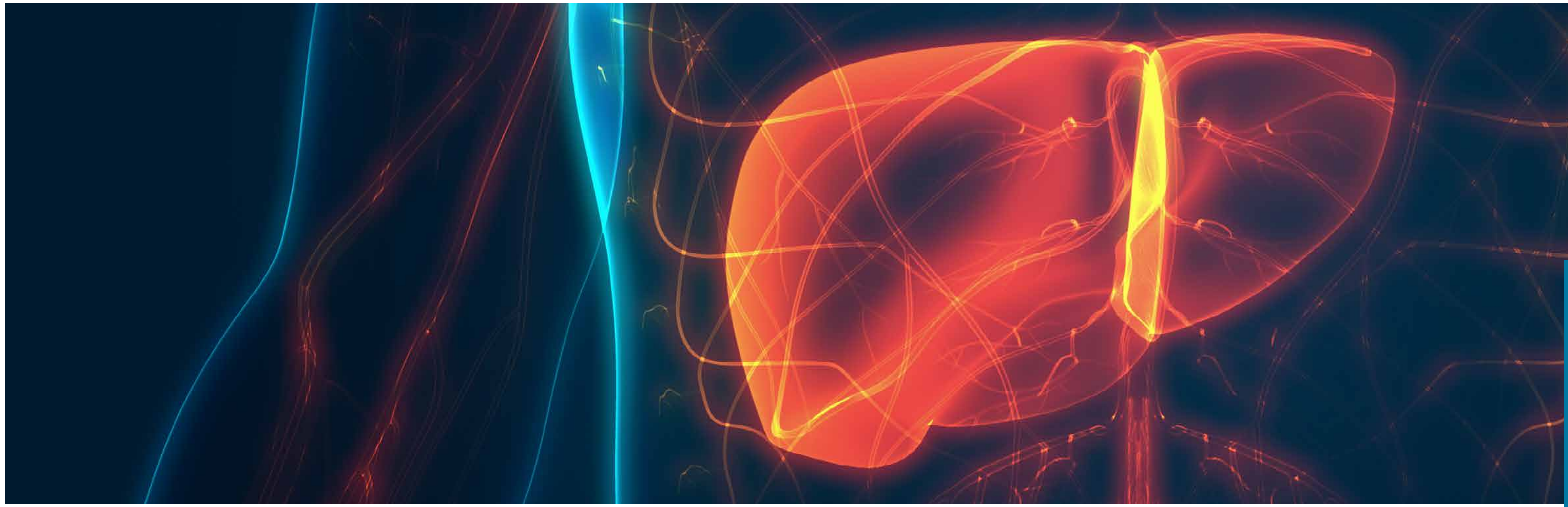
Medical Image Analysis with Computer Vision

Computer vision benefits are indispensable in the healthcare industry, where an accurate and timely diagnosis can save lives. A medical facility in Taiwan has adopted a computer vision solution developed by Intel and QNAP/IEI to optimize the identification of a dangerous eye disease. As the symptoms usually show up in the late stages, the condition is confirmed too late when the disease is not treatable.

Solution:

By training a deep learning algorithm on images with tell-tale signs of the disease, the facility deployed a computer vision solution that analyzed optical coherence tomography results with high accuracy and precision. Now that the previously time-consuming and labor-intensive diagnostic task is enhanced, patients can get their results in one day at an acceptable price and receive timely treatment.

CASE STUDY #6



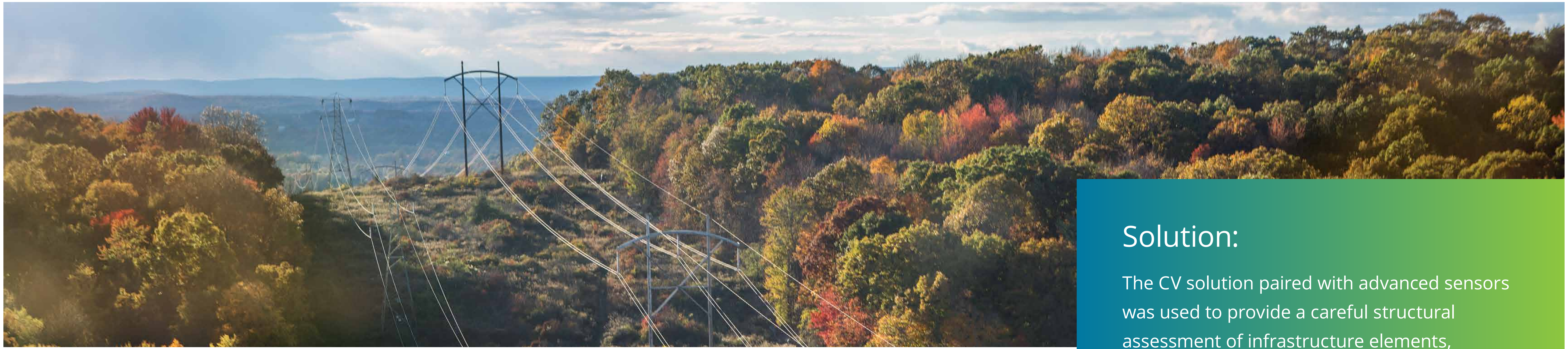
Improved Tumor Evaluation with an AI-powered Solution

Artificial Intelligence is gaining traction in oncology to optimize manual tumor evaluation, an intensive workload prone to subjectivity. Amsterdam University Medical Center adopted a computer vision solution provided by SAS to increase the accuracy of identifying liver cancer markers.

Solution:

Withing the deep learning model, the image segmentation technique was used to break down images into segments and analyze every pixel of them for the slightest tumor characteristics. The resulting image is represented as a 3D liver model with a pinpointed tumor with/without metastasis. In this way, computer vision acts as a radiologist augmentation providing faster and more accurate interpretations for further treatments.

CASE STUDY #7



Equipment Intelligence for Energy Providers

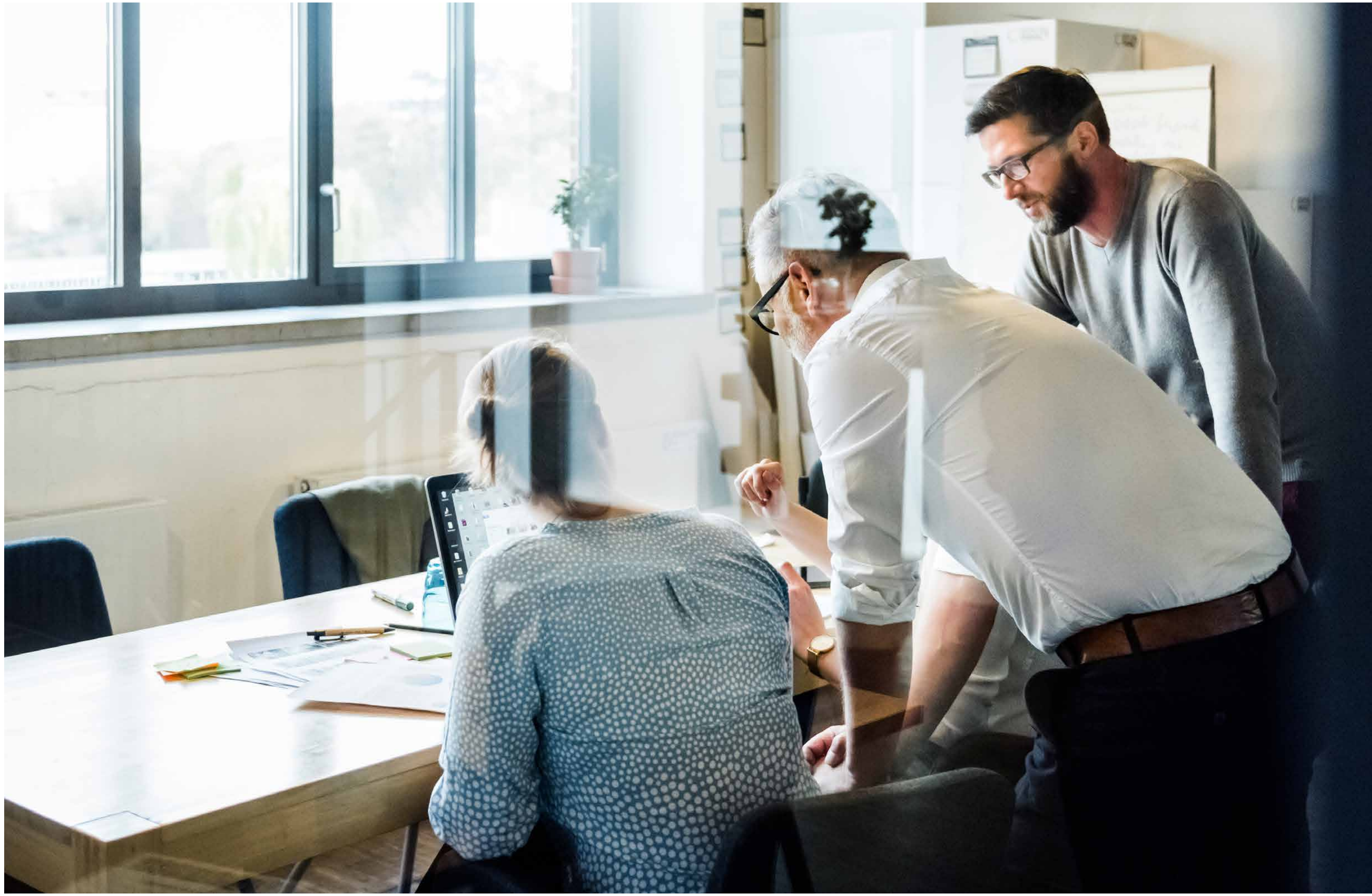
Power quality and network stability are closely linked to energy providers' maintenance and management practices. IoT and computer vision tandem brings vital efficiency and productivity to asset management and equipment monitoring in the energy industry. PwC has supplied energy providers with computer vision drones to get better visibility across their networks.

Solution:

The CV solution paired with advanced sensors was used to provide a careful structural assessment of infrastructure elements, validation of structural alignment, detection of overheating elements, and corrosion identification. By adopting this advanced technological approach, energy providers can now mitigate critical operational risks effectively and in a timely manner.

Conclusion

Advanced visual AI systems are steadily paving their way as intelligent assistants for numerous industries, from manufacturing and retail to healthcare. The contemporary development level of machine learning algorithms allows enterprises to entrust computer vision with continuous control, real-time monitoring, insightful analytics, and more. Thanks to smart cameras, companies can automate routine processes, significantly cut costs, ensure production safety and business continuity, and achieve an outstanding competitive advantage.



About Infopulse

Since 1991, Infopulse has been providing cutting-edge IT services, helping our clients worldwide embrace the latest technology. Our Cognitive Computing Competence Center includes the broadest range of Data Science, Computer Vision, NLP, Predictive Intelligence services, and more, as Infopulse strives to offer our clients Artificial Intelligence as a Service (AIaaS) and advanced cognitive solutions. Our experience in numerous domains and verticals allows us to assure the finest quality of intelligent solutions and services, aligned with the customers' strategic goals and business needs.

Contact us today to plan your tomorrow's success!

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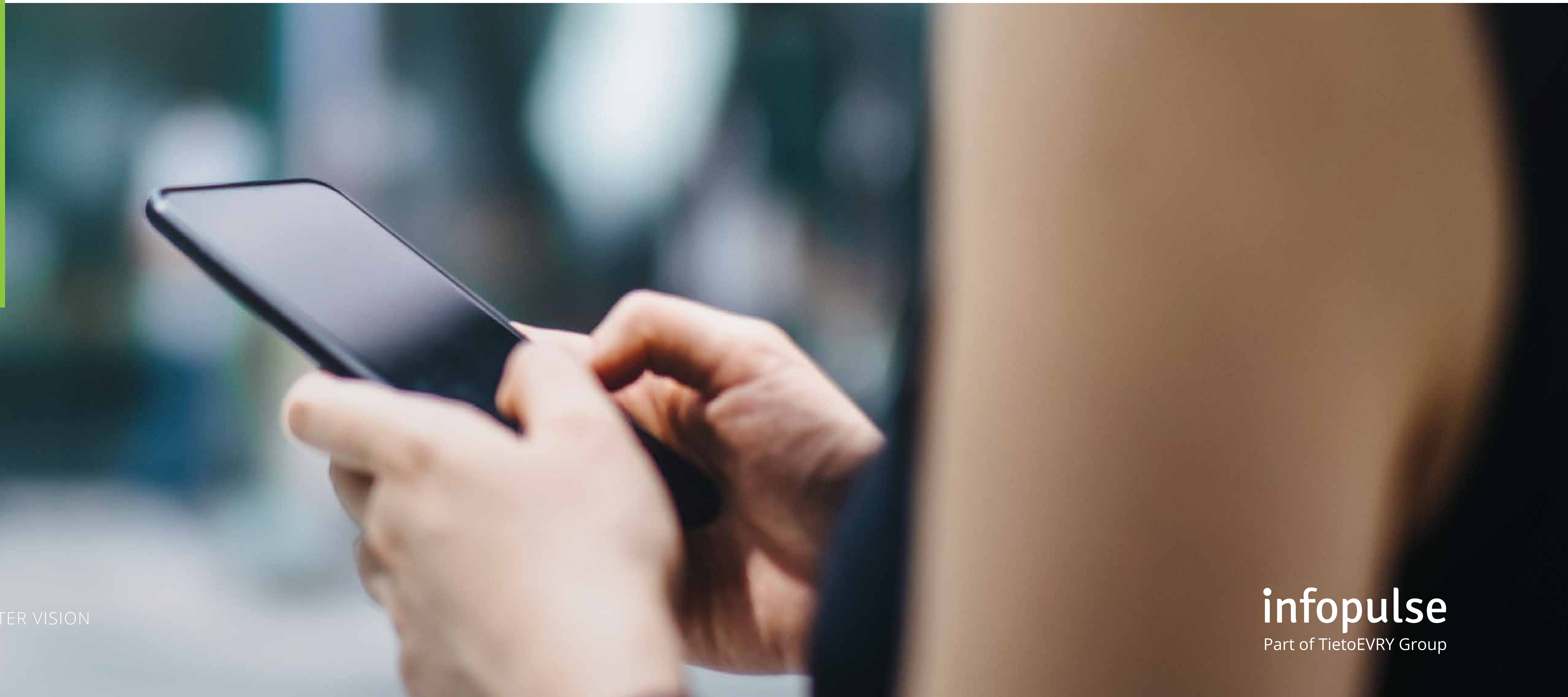

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